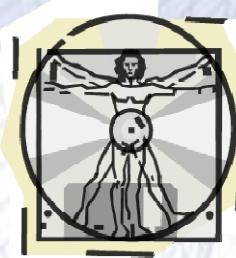


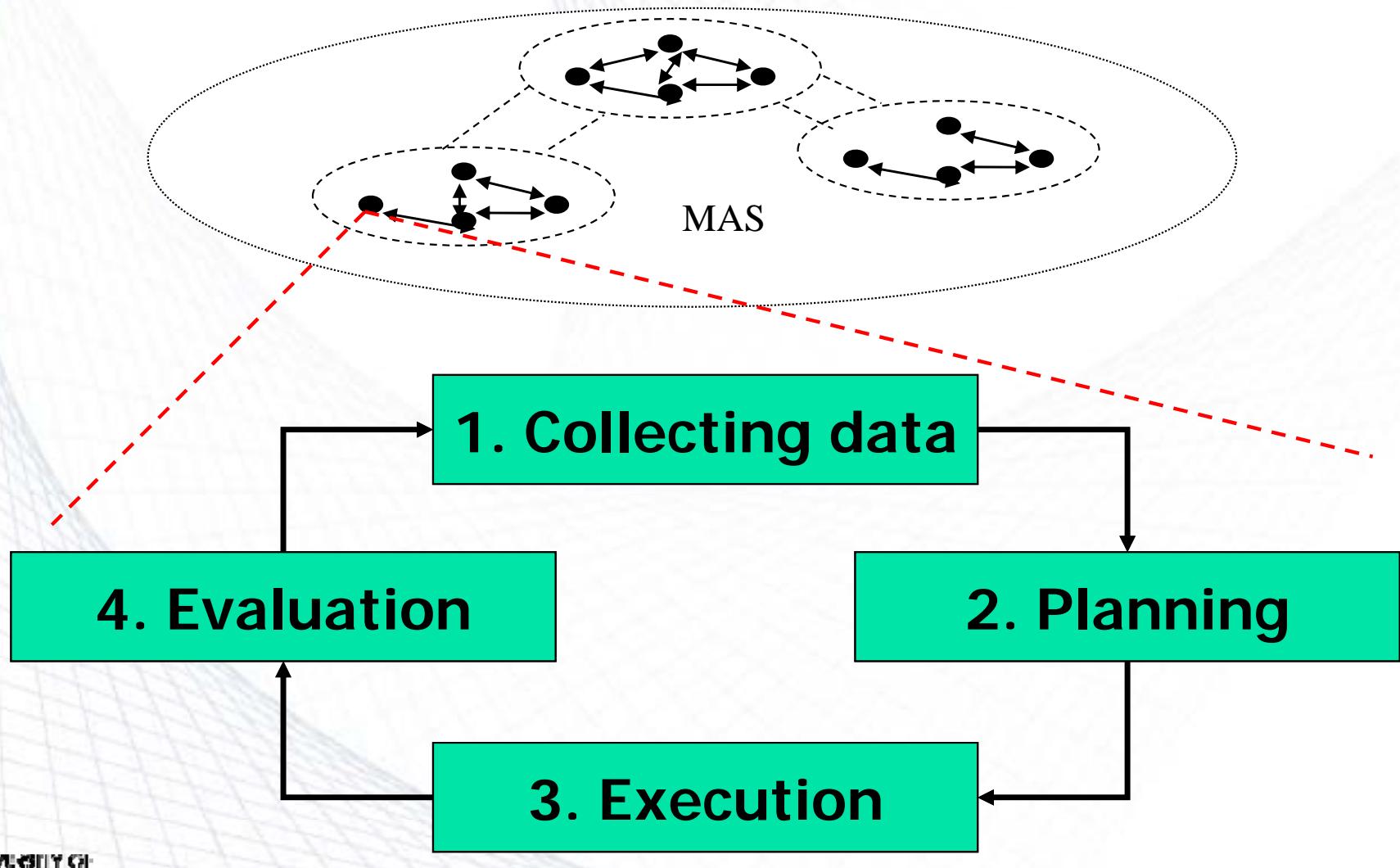


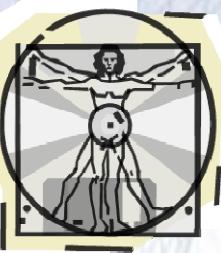
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# Indeterminism: Agent Decision Making Process



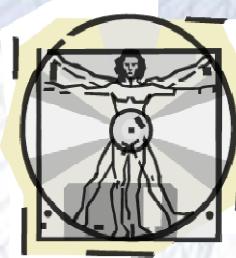
# Decision Making Process





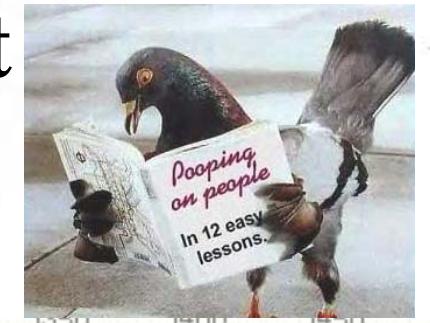
# Decision Making Process (contd.)

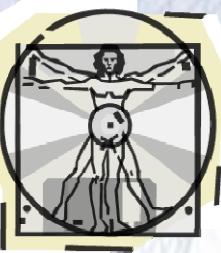
- Planning step:
  1. Organizing and interpreting data/information.
  2. Building the representation model based on different options (i.e. class of games in game theory, utility theory or other uncertainty management theories).
  3. Calculating the expected utilities of possible alternative solutions associated with each option, selecting the *best* one, and using it to select a proper action.



# Decision Making Under Certainty

- Use Game Theory
- Agents may take their action simultaneously or in sequence: either strategic game or extensive game can be used.
- ***Strategic game:*** the agent chooses a strategy that optimizes its utility (**Nash Equilibrium**)
- ***Extensive game:*** the agent chooses a strategy according to the **Subgame Perfect Equilibrium**

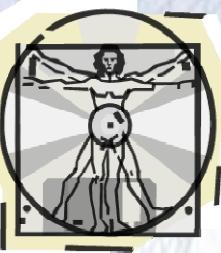




# Decision Making Under Uncertainty (without Risk)

- Use Utility Theory
- Decisions (selecting an action) depend on:
  - What the agent knows (beliefs about various states of the world)
  - What the agent wants (desires; goals)
- We can represent beliefs by *probabilities*
- We can represent desires by *utilities* (*i.e.* benefit or value)

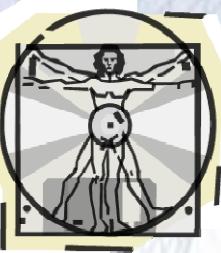




# Decision Making Under Uncertainty (without Risk)

- Maximize expected value of the act
  - When considering an act, take into account both the *probability* and the *utility* of each possible consequence.
  - Multiply the probability of each consequence by its utility and then adding them all up.
  - Select the strategy with highest expected value
- This is certainly a “rational” choice but may not be always the “best” one!
- It depends on how we define “utility”
- *It may not necessarily be irrational to act even when the expected value of the act is negative.*

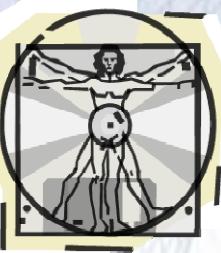




# What is Risk?

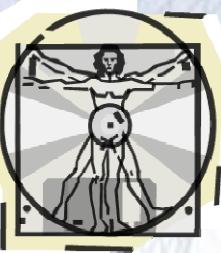
- Risks risk is a combination of an abnormal event or failure and the consequences of that event or failure to a system's operators, users, or environment. A risk can range from catastrophic to negligible. Risks are also categorized according to the likelihood of occurrence. [David Gluch]

Severity	Likelihood of Occurrence			
	Probable	Occasional	Remote	Improbable
Catastrophic	High	High	High-Medium	Medium
Critical	High	High-Medium	Medium	Medium-Low
Marginal	High-Medium	Medium	Medium-Low	Low
Negligible	Medium	Medium-Low	Low	Low



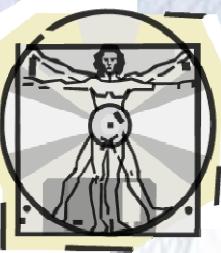
# Decision Making Under Uncertainty (with Risk)

- What if the expected values of two strategies are the same?
- Example:
  - Consider a case where you toss a fair coin and win \$1,000,000 if it comes up heads and lose \$1,000,000 if it comes up tails.
  - The expected value of “win” and “lose” strategies are equal.
  - The expected value rule says that each choice is of equal value and you should not prefer one to the other.
- Is this right?



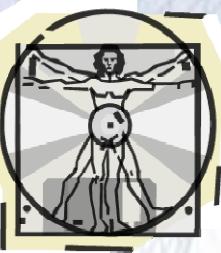
# Decision Making Under Uncertainty (with Risk)

- Decision depends on our *attitude towards risk*
- May be you think, then losing \$1,000,000 is far worse than gaining \$1,000,000 or the other way round
- Therefore, the risk of losing might outweigh the benefit of winning even though both are equally probable



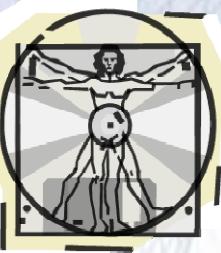
# Decision Making Under Uncertainty (with Risk)

- The agent's attitude towards risk can be categorized into the following three types:
  - **Risk prone:** In this case, agent prefers **high-risk high-return** strategy rather than low-risk low-return strategy.
  - **Risk averse:** In this case, agent prefers **low-risk low-return** strategy rather than high-risk high-return strategy.
  - **Risk neutral:** If expected value is the same neither can be selected.



# Decision Making Under Uncertainty (with Risk)

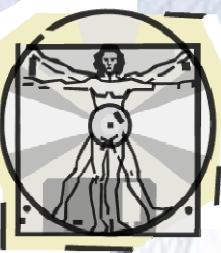
- ***Maximin return*** (assume the worst state of nature: Select alternative that will maximize the minimum payoff)
- ***Optimism-pessimism index*** (optimism: select alternative that will maximize the maximum payoff; pesimism: Select alternative that will maximize the minimum payoff)
- ***Minimax regret*** (don't want to regret too much: select alternative that will minimize the maximum regret)
- ***Laplace's principle of insufficient reason*** (assume equal likely states of nature: select alternative with best average payoff)
- Etc.



# Decision Making Under Uncertainty

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- What if we don't know the probabilities?
- Can belief be evaluated without using the probabilities?
- According to cognitive psychology, when probability distribution is not known, people evaluate belief based on
  - **Degree of comfort** (i.e., selecting the one that needs the least effort)
  - **Degree of optimism** (i.e., selecting the one that we think is the most “fit” given a fitness criteria)
- How to quantify degree of optimism/comfort?



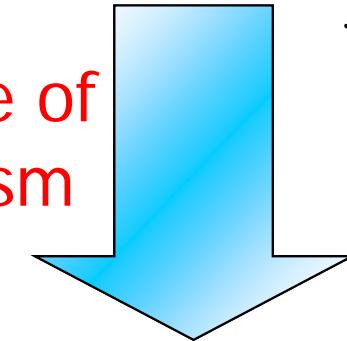
# Decision Making Under Uncertainty

- Using Ordered Weighted Averaging (OWA) method [Yager]
- Using OWA we can order the choices according to the best thing happening first, i.e., the best choice has the highest weight
- Use the weights as pseudo-probabilities

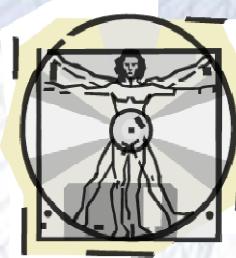
$$\vec{W} = [w_1, \dots, w_n]$$

$$F(a_1, \dots, a_n) = \sum_j w_j b_j$$

Degree of optimism



$$Opt(W) = \sum_j w_j \frac{(n-j)}{(n-1)}$$



# Agent Decision Making

## Conclusion

- Decision making is more than following an algorithmic path ← unlike ordinary programs
- Decision making is also more than reasoning ← unlike expert systems
- A library of decision making mechanisms is needed to facilitate implementation of the decision making behavior of software agents